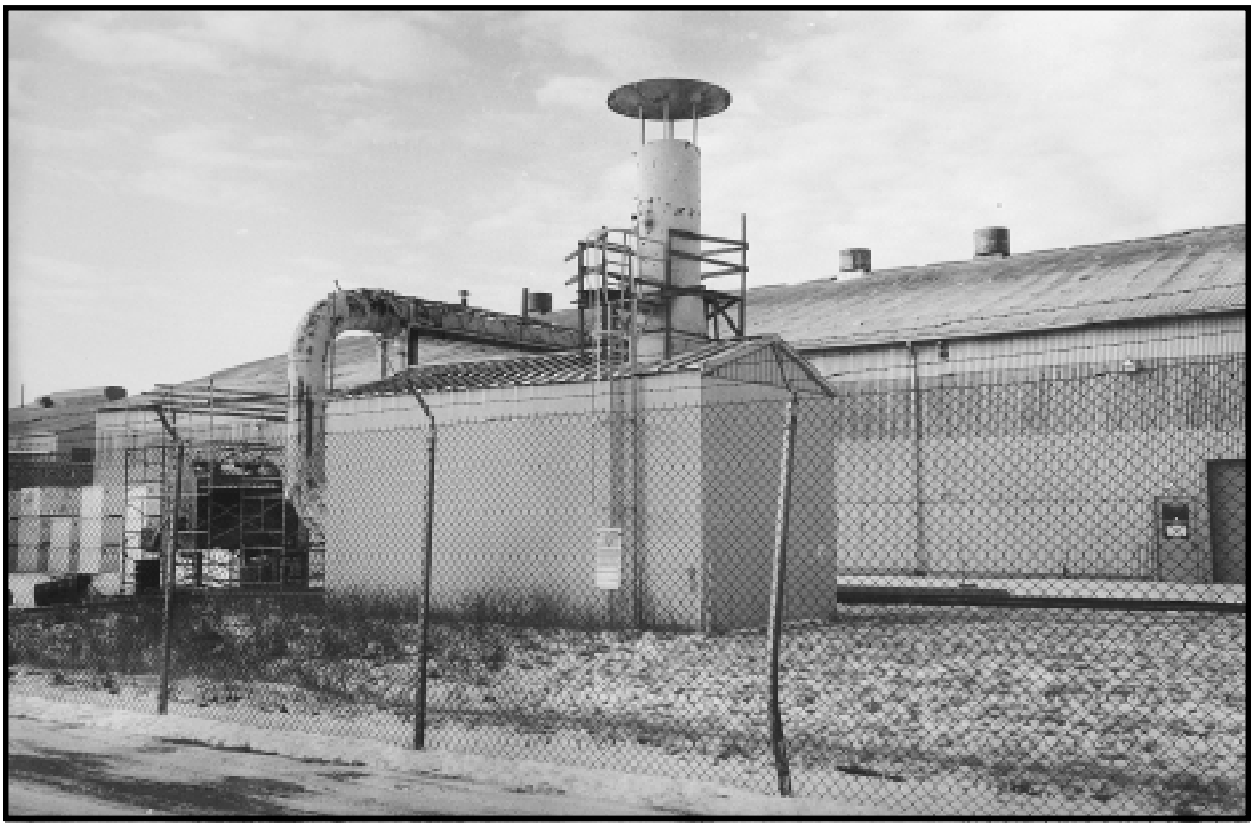
4. Contaminated Environmental Media



Plant 9 exhaust stack. This exhaust stack was used to control emissions from the Fernald's Plant 9 facility, which processed enriched uranium materials. The malfunctioning of systems like this resulted in releases of several hundred tons of uranium dust to the environment outside the plant buildings over the course of three decades of operations. *Fernald Plant, Ohio. December 30, 1993.*

Overview

Hazardous and radioactive substances from nuclear weapons production, research, development, and testing activities and other Department of Energy (DOE) nuclear and nonnuclear programs have contaminated environmental media (including soil, sediment, groundwater, and surface water) on and around DOE sites. Some waste streams were discharged to the environment with or without prior treatment. These include relatively small, localized releases that may have resulted from accidents; larger planned releases of process effluents; and releases on a much larger scale, such as atmospheric fallout from nuclear weapons tests. In other cases, containment systems such as tanks, drums, or landfills lost their integrity and waste leaked into adjacent soil and water. Contaminated media also resulted from spills and other inadvertent releases during process operations or maintenance.

Contaminated environmental media are primarily water and solids (including soils). Nuclear weapons production activities have resulted in a legacy of 1,500 million cubic meters of contaminated water and 73 million cubic meters of contaminated solid media. Nonweapons activities by the Department and its predecessor agencies have contaminated an additional 350 million cubic meters of water and 5.8 million cubic meters of solid media.

In some cases, a single activity that was performed for both the nuclear weapons and nonweapons programs contaminated environmental media. For example, the same facilities simultaneously enriched

Key Observations of the Contaminated Media Legacy

- The Department of Energy manages about 79 million cubic meters of contaminated solid media (73 million cubic meters from weapons production and about 5.8 million cubic meters from nonweapons activities) and about 1,800 million cubic meters of contaminated water (1,500 million cubic meters from weapons production and 350 million cubic meters from nonweapons activities). Most of the solids are soil and most of the water is groundwater.
- The total of about 1,900 million cubic meters of contaminated media is approximately 50 times larger in volume than the Department's 36 million cubic meters of waste; however, groundwater constitutes approximately 96 percent of the media legacy. The management requirements and options for water differ significantly from those for solid media and waste.
- Contaminated environmental media from nuclear weapons activities are located at 64 DOE environmental management sites in 25 states, including contaminated water at 39 sites and contaminated solids at 40 sites. Contaminated media from nonweapons activities are located at 37 of these sites. Contaminated media from nonweapons activities only are located at an additional 32 sites.
- The Department is assessing the presence of contaminated media or waste at about 9,900 release sites and other units. Work at 2,800 of these sites is complete as of 1996.
- The contaminated media element includes different types of contamination, including widespread but diffuse groundwater and soil contamination and atmospheric fallout, some of which are not included quantitatively in this report. Remediation decisions have not yet been made for some of this contamination. In other cases, remediation is either unnecessary or impractical.

uranium for nuclear weapons, the Naval Nuclear Propulsion Program (NNPP), and commercial nuclear power reactors. The amounts of contaminated environmental media resulting from these multipurpose activities were apportioned in this analysis to determine the volumes attributable to nuclear weapons and nonweapons activities. The methodology section of this chapter lists the data sources and documents the process used to determine the volume, characteristics, and sources of the media legacy.

The Department of Energy is now remediating contaminated environmental media through treatment, removal, and containment-oriented actions. Treatment may remove contaminants from the media or immobilize contaminants within it. In some cases, the media themselves are removed from the environment and treated or stored before final disposal. Given current resources, technology, and priorities, however, the treated media often cannot be returned to the original conditions. If contaminant concentrations and risks are low and regulators concur, DOE often decides not to treat contaminated media. Instead, protection is provided by monitoring contaminant movement and reducing or preventing human exposure through containment or institutional controls. The text box provides observations on the legacy of contaminated environmental media resulting from the activity of DOE and its predecessor agencies.

Definitions and Categories

Contaminated Environmental Media

Contaminated environmental media are naturally occurring materials such as soil, sediment, surface water, groundwater, and other in-place materials (e.g., sludge and rubble/debris that have been disposed of and/or are intermixed with soil) that are contaminated at levels requiring further assessment to determine whether an environmental restoration action is warranted. Contaminated environmental media do not include materials being managed as waste under the Department's Environmental Restoration Program, such as mill tailings, stored waste that have not been disposed of, and waste already sent to commercial facilities or managed under the Department's Waste Management Program. Also excluded are materials that may have economic value, standing structures and equipment, sanitary waste, or construction/demolition debris.

Materials that were previously disposed of but are currently in the Environmental Restoration Program for further assessment with regard to long-term disposition are considered contaminated media. This

status continues unless or until the material is removed, at which time it would be managed as waste.[1] Some waste is very similar to environmental media. For example, 11e(2) byproduct material at a uranium milling site is considered waste; similar material at a non-mill tailing site is considered waste if it is stored but is considered environmental media if it is in place.

The legacy of contaminated environmental media includes media that the Department is managing or is likely to manage actively in the future as well as some media for which no further action is expected. It includes both contaminated media within current DOE site boundaries and some media outside of site boundaries (see text box "Offsite Contamination around DOE Sites").

The Department's Environmental Restoration Core Database maintains most of the information on contaminated media volume used in this report. This database includes data on all contaminated environmental media within the scope of the current Environmental Restoration Program. However, there are additional contaminated media outside the scope of this program, such as areas for which remedial actions have been determined to be unnecessary or infeasible. The Core Database does not include information for such areas. The Department has obtained estimated volumes for most of this category of contaminated environmental media from other sources, but some of the media remain unquantified.

An air-monitoring station at the Fernald plant boundary measures airborne radioactivity exiting the plant property.
Fernald Plant, Ohio. December 29, 1993.

[1] *The Waste Management Program and the Environmental Restoration Program track some materials at waste disposal sites that have been closed and are in line for assessment. This report includes these materials as waste (Chapter 3) and contaminated media (Chapter 4). The Waste Management Program tracks the volume and radioactivity of disposed waste, while Environmental Restoration Program estimates the total volume requiring assessment. (The volume of material to be assessed is typically larger than the disposed waste volume.) Thus, some of these materials are double-counted in this report. The largest volumes of double-counted material include disposed transuranic waste at INEL and disposed low-level waste at Hanford Site, SRS, FEMP, LANL, and Y-12 Plant. Although the exact amount is not known, the double-counted materials constitute no more than a few percent of the contaminated media legacy.*

Equalization pond. *Weldon Spring Quarry, near the Weldon Spring Site, St. Charles County, Missouri. January 29, 1994.*

Categorization and Quantification of Contaminated Environmental Media

In this report, contaminated environmental media are quantified in two ways—by the volume of media and by the number of release sites and other units where contamination is potentially present. Each measure provides a different perspective on the contaminated environmental media legacy.

Offsite Contamination around DOE Sites

Environmental media outside of the boundaries of several DOE sites have been contaminated as a result of onsite activities. At DOE's Paducah Gaseous Diffusion Plant in Kentucky, for example, groundwater has become contaminated by technetium-99, a long-lived radioisotope present in uranium recovered from reprocessed spent fuel, and trichloroethylene, a hazardous cleaning solvent that was once commonly used at the site. The contamination resulted from leaks, waste disposal, and discharges that occurred onsite many years ago. Over time, the contaminants infiltrated to groundwater that flowed northward under the site. After the contaminants reached the groundwater, they began to gradually disperse until several large plumes of contaminated groundwater had formed. DOE has been investigating the contamination for several years to identify the sources and has begun interim removal of the contaminants and control of the groundwater plumes. Until a final decision on remediation of the contamination is reached and implemented, DOE is providing an alternative water supply to the public where the groundwater contamination has reached hazardous levels.

Other sites known to have offsite contaminated media include Fernald, Hanford, Kansas City Plant, Los Alamos National Laboratory, Brookhaven National Laboratory, Lawrence Livermore National Laboratory, Mound, Oak Ridge National Laboratory, Pantex Plant, Rocky Flats Environmental Technology Site, the Savannah River Site, and the Oak Ridge Y-12 Plant.

Media Volume

When measured by volume, contaminated media are categorized according to physical matrix and type of contamination. These two factors, together with site-specific conditions, determine management requirements and alternatives. There are two major categories of physical matrices: water and solid media. Within these two broad categories, the Department tracks 27 specific physical matrices of media as shown in Table 4-1. The vast majority of the Department's contaminated environmental media fall into the categories of groundwater and soil.

A broad range of contaminants is present in media, but they can generally be categorized as radioactive or hazardous.[2] Some media are contaminated by both radioactive and hazardous constituents while others contain only one type of contamination.

Improving waste management to prevent future contamination. Since 1951, more than 200 million gallons of slightly radioactive water from Hanford's high-level waste tanks were routinely discharged into the soil. Such discharges contributed to Hanford's extensive soil and groundwater contamination. To limit further contamination, Hanford began treating this type of wastewater in April 1994 to remove radionuclides and chemicals before discharging it. Prior to treatment, wastewater is stored in these three 6.5 million gallon, double-lined basins with floating covers and a leachate collection system. *Liquid Effluent Storage Facility, 200 Area, Hanford Site, Washington. July 12, 1994.*

Release Sites and Other Units

This report quantifies contaminated media according to five different types of units where contamination is potentially present: (1) release sites; (2) FUSRAP sites; (3) UMTRA surface contamination sites; (4) UMTRA groundwater contamination sites; and (5) facilities.

A release site is a unique location at which a hazardous, radioactive, or mixed waste release has or is suspected to have occurred. A release site is usually associated with an area where waste or substances contaminated with waste have been disposed of, treated, stored, or used. Under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), release sites include both source areas and areas of migration where hazardous and/or radioactive substances have come to be located. A release site typically includes the actual geographic area covered by a source and the extent of

[2] *Although they are not "hazardous" under RCRA, asbestos, and PCBs are considered in the "hazardous" contaminants in this chapter.*

associated contamination as delineated during the characterization process. It may include areas in very close proximity to the contamination that are necessary for implementing a response action. Release sites may include corrective action units, solid waste management units, areas of concern, or other unit categorizations applied under CERCLA or the Resource Conservation and Recovery Act corrective action process. Within this definition, DOE sites may adopt their own site-specific counting methods. There are usually many release sites at an individual DOE site.

FUSRAP and UMTRA manage FUSRAP sites, UMTRA surface contamination sites, and UMTRA groundwater contamination sites. Unlike most DOE sites at which several or many release sites are located, each site in the FUSRAP program is counted as a single site, and each site in the UMTRA Project is counted as one UMTRA surface contamination site and one UMTRA groundwater contamination site (although assessment of the Lowman, Idaho, UMTRA site has determined there is no groundwater contamination at the site).

The final unit is the facility. Although facilities are addressed in Chapter 5, in some cases the contaminated media present around or underneath a facility are considered part of the facility and are not counted as a release site or FUSRAP or UMTRA site. Facilities are included to provide a more complete estimate of the number of units encompassed by this element. (Table 4-2).

Table 4-1. Physical Matrices of Contaminated Media

Water	Solid Media*	
Groundwater**	Asbestos	Rubble/Debris
Liquid	Asphalt	Salts
Surface Water	Concrete/Brick	Sediment
Wastewater	Gas	Sludge
	Metal	Soil**
	Paper/Cloth	Wood
	Residues	Other Solid

* *No inventories are currently assigned to the following subcategories, which are also included in the solid media category: absorbent, compost, filters, kao/wool, personnel protective equipment/filters, resins, solid chemical, solvents/oils, and vapor.*

** *Soil and groundwater comprise 99% of the total volume of contaminated environmental media in the DOE Environmental Management Program.*

Table 4-2. Release Sites and Other Units

Type of Unit	Number of Units
Release Sites	8,727
FUSRAP Sites	46
UMTRA Surface	24
UMTRA Groundwater	24
Facilities	1,077
TOTAL	9,898

The total legacy of contaminated environmental media managed by the Department of Energy includes approximately 7,200 units resulting from nuclear weapons production and 2,700 units from nonweapons activities. Contaminated media are not known to be present at all these units. In some cases only waste is present.

RESULTS

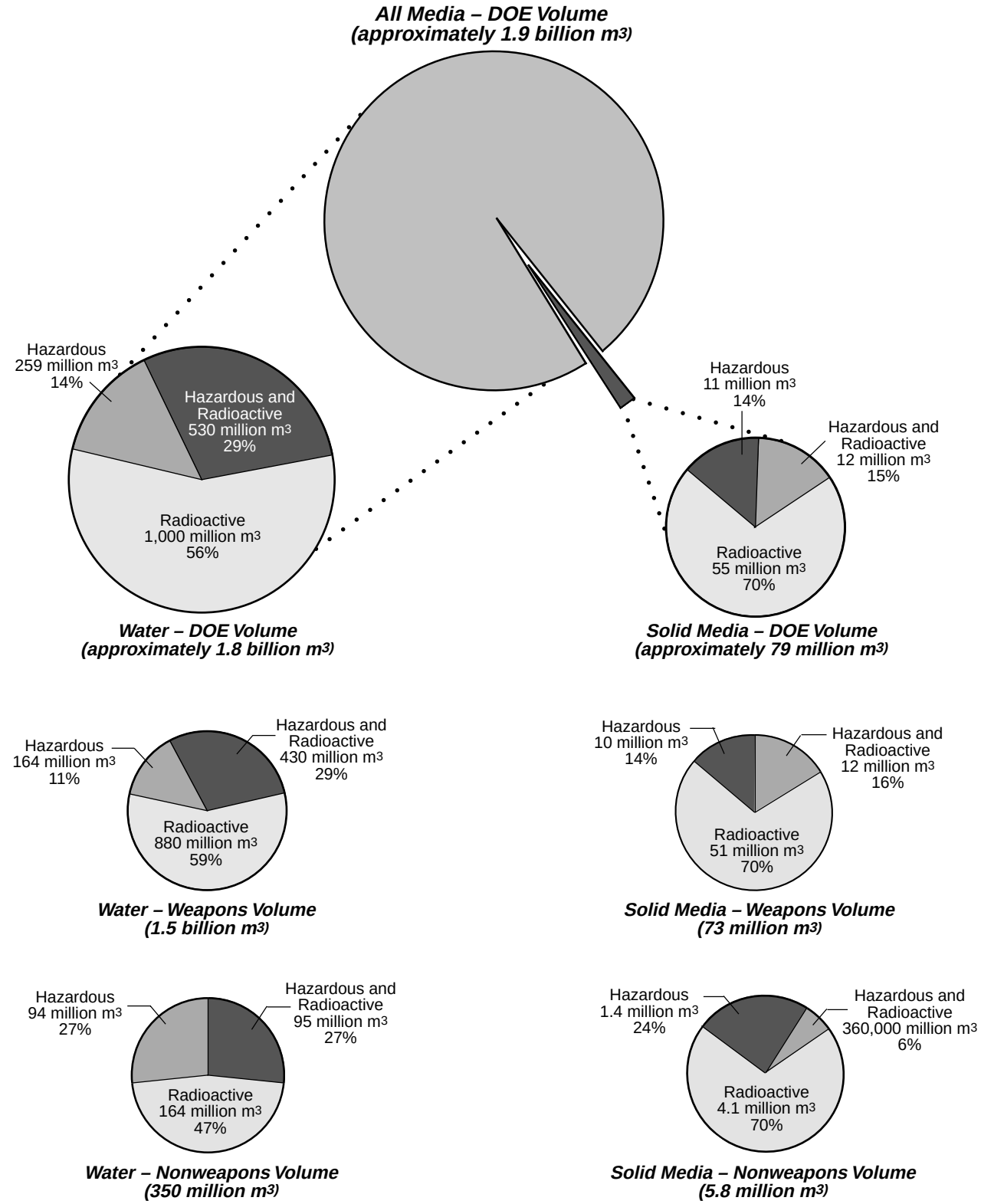
The results in this chapter include a quantitative analysis of the source, composition, and locations of the contaminated environmental media by both volume and number of release sites and other units. This information was obtained from the Department's Environmental Restoration Core Database and was supplemented by information from other sources.

Volume of Water and Solid Media

Figure 4-1 presents the relative volumes of the two major categories of contaminated environmental media that have been quantified. The volume of contaminated water (1,800 million cubic meters) is about twenty-three times the amount of the contaminated solid media (79 million cubic meters).

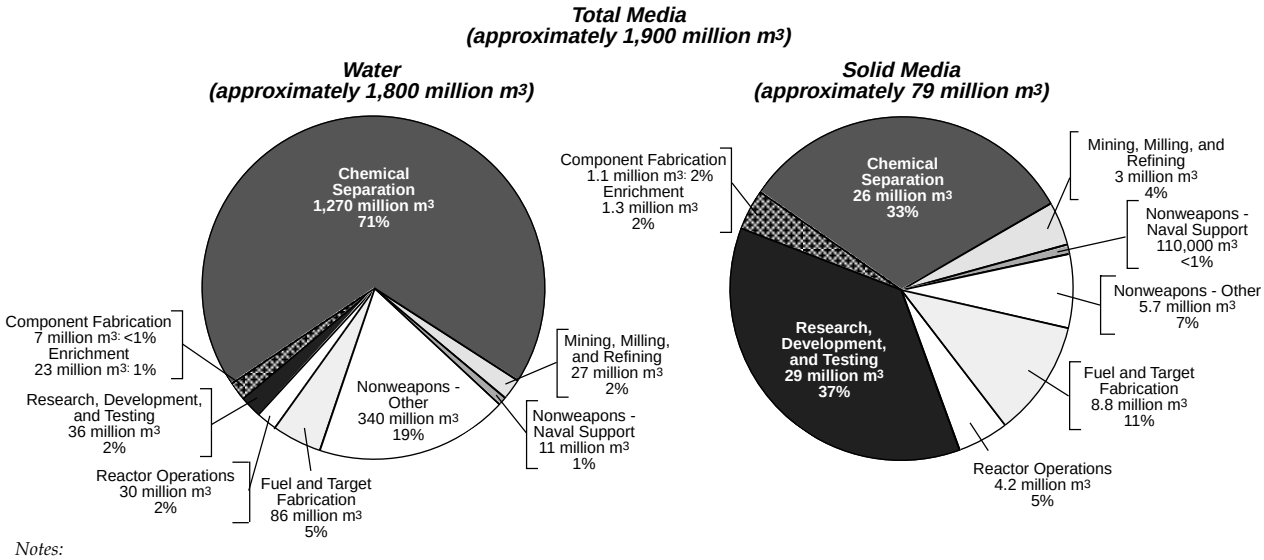
The contaminated environmental media from nuclear weapons production contains hazardous and radioactive constituents (Table 4-3) .

Figure 4-1. Composition of Contaminated Media



Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996.
(2) Media volume calculations subject to Endnotes a, b, and c.
(3) Weapons allocations are subject to Endnotes e, f, and g.
(4) Includes approximately 1,500 million cubic meters of water and 15 million cubic meters of solid media outside the scope of the current DOE Environmental Restoration Program.

Figure 4-2. Contaminated Environmental Media Categorized by Process



Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996.
(2) Media volume calculations subject to Endnotes a, b, and c.
(3) Nuclear weapons allocations are subject to Endnotes e, f, and g.
(4) Includes approximately 1,500 million cubic meters of water and 15 million cubic meters of solid media outside the scope of the Environmental Restoration Program.

Table 4-3. Categorization of Contaminated Media

Category	Volume	Includes:
Hazardous[b]	Liquid: 164 million m^3 Solid: 10 million m^3	Asbestos[a] RCRA Hazardous PCB
Radioactive	Liquid: 880 million m^3 Solid: 51 million m^3	11e(2) Byproduct Material LLW
Radioactive and Hazardous[c]	Liquid: 430 million m^3 Solid: 12 million m^3	TRU MLLW Radioactive Asbestos Radioactive PCB
Neither Radioactive nor Hazardous	Excluded from analysis[c]	Mixed TRU Demolition Sanitary Not Applicable

[a] *"Waste type" as assigned in the Environmental Restoration Core Database.*

[b] *Although they are not "hazardous" under RCRA, asbestos and PCBs are included in these categories.*

[c] *These materials are excluded because they can be managed without special consideration of their hazardous or radioactive characteristics.*

About 84 percent of the water and 91 percent of the solid media were contaminated by weapons production (Figure 4-1). The weapons production process categories that resulted in the most contaminated media are chemical separation (71 percent of the water and 33 percent of the solid media); fuel and target fabrication (5 percent of the water and 11 percent of the solid media); and research, development, and testing (2 percent of the water and 37 percent of the solid media) (Figure 4-2). No contaminated media are attributed to weapons operations.[3]

Contaminated media attributed to nonweapons activities come from a wide range of sources; only a small amount is attributed to support for the Naval Nuclear Propulsion Program (NNPP). (None of the contaminated environmental media volume attributed to supporting the NNPP resulted from operations conducted by or under the purview of the NNPP. Instead, these media resulted from activities managed by other DOE programs.)

Contaminated media from nuclear weapons production are located at 64 environmental management sites in 25 states (Tables 4-4 and 4-5). Sites and states with the largest amounts of contaminated environmental media are Hanford in Washington (1,200 million cubic meters of contaminated water and 20

[3] *While there is evidence of explosive contamination in perched groundwater at Pantex, it is believed to be the result of the site's use as a conventional munitions factory during World War II.*

million cubic meters of contaminated solid media) and the Savannah River Site in South Carolina (200 million cubic meters of contaminated water and 19 million cubic meters of contaminated solid media). Other states with large amounts of contaminated media from nuclear weapons production include California (25 million cubic meters of contaminated water at two sites, primarily at Lawrence Livermore National Laboratory), Kentucky (19 million cubic meters of water at Paducah), New Mexico (10 million cubic meters of solid media at two sites, primarily at Lawrence Livermore), and Colorado (14 million cubic meters of contaminated water at nine sites).[4]

Table 4-4. Contaminated Solid Media Resulting from Weapons Production

Sites	Nuclear Weapons Volume (m^3)	Nonweapons Volume (m^3)	Total
Amchitka Island (AK)	4,600	2,300	6,900
Ashland 1 (NY)	92,000		92,000
Ashland 2 (NY)	40,000		40,000
B&T Metals (OH)	1,700		1,700
Central Nevada Test Site (CNTS) (NV)	6,100		6,100
DuPont (NJ)	6,300		6,300
Fernald (OH)	2,100,000		2,100,000
Hanford (WA)	20,400,000	3,200,000	23,600,000
Idaho National Engineering Site (ID)	510,000	210,000	720,000
K-25 Site (TN)	5,500	2,800	8,300
Kansas City Plant (MO)	28,000		28,000
Kauai Test Facility (HI)	1,400		1,400
Latty Avenue Properties (MO)	140,000		140,000
Lawrence Livermore National Laboratory - Main Site (CA)	2,200,000		2,200,000
Lawrence Livermore National Laboratory - Site 300 (CA)	12,000		12,000
Linde Air Products (NY)	57,000		57,000
Los Alamos National Laboratory (NM)	9,900,000		9,900,000
Luckey (OH)	26,000		26,000
Middlesex Sampling Plant (NJ)	17,000		17,000
Mound (OH)	110,000		110,000
Nevada Test Site (NV)	16,000,000	40,000	16,000,000
New Brunswick Laboratory (NJ)	3,100	340	3,440
Oak Ridge National Laboratory (TN)	380	72,000	73,000
Oak Ridge Reservation (TN)	50,000	7,300	57,300
Oxnard (CA)	76		76
Paducah Gaseous Diffusion Plant (KY)	600,000	390,000	990,000
Pantex (TX)	110,000		110,000
Portsmouth Gaseous Diffusion Plant (OH)	15,000	9,800	24,800
RMI (OH)	29,000		29,000
Rocky Flats Environmental Technology Site (CO)	460,000		460,000
Sandia Nationa Laboratories - Albuquerque (NM)	210,000		210,000
Sandia Nationa Laboratories - Livermore (CA)	11,000		11,000
Savannah River Site (SC)	19,000,000		19,000,000
Seaway Industrial Park (NY)	89,000		89,000
Site A / Plot M (IL)	540		540
St. Louis Airport Site (SLAPS) (MO)	190,000		190,000
St. Louis Airport Site (Vicinity Properties) (MO)	150,000		150,000
St. Louis Downtown Site (SLDS) (MO)	170,000		170,000
Ventron (MA)	1,700		1,700
Weldon Spring Site (MO)	480,000		480,000
Y-12 (TN)	19,000		19,000
TOTAL WEAPONS	58,000,000	3,900,000	62,000,000
TOTAL OTHER NONWEAPONS SITES	0	1,800,000	1,800,000
TOTAL DOE	58,000,000	5,800,000	64,000,000

Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996.
(2) Media volume calculations subject to Endnotes a, b, and c.
(3) Weapons allocations are subject to Endnotes e, f, and g.
(4) B&T Metals is complete. Ventron and New Brunswick to be completed Fall of 1996.
(5) Includes approximately 1,500 million cubic meters of water and 15 million cubic meters of solid media outside the scope of the Environmental Restoration Program.

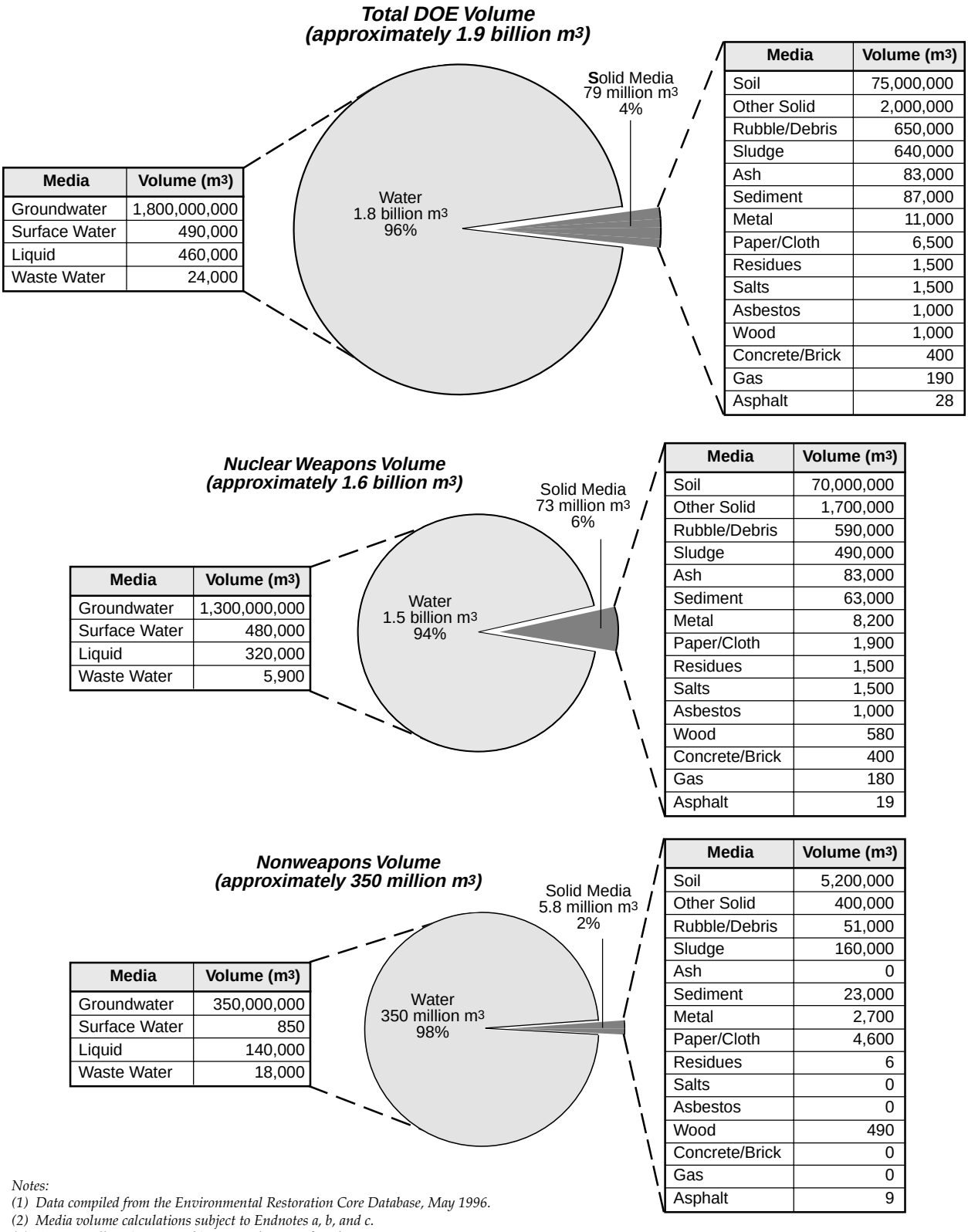
Sites and states with the largest amounts of contaminated environmental media from nonweapons activities include Washington (3.2 million cubic meters of contaminated solid media and 210 million cubic meters of contaminated water at Hanford), Idaho (34 million cubic meters of contaminated water and 210,000 cubic meters of contaminated solid media at INEL), and California (3.0 million cubic meters of contaminated water at two sites and 190,000 cubic meters of contaminated solid media at six sites).[5]

Although the contaminated environmental media legacy from nuclear weapons production is composed of nearly 20 different physical material matrices, 99 percent of the 1,900 million cubic meters are either groundwater or soil (Figure 4-3). Contaminated water from weapons production is over 99 percent

[4] *The nine Colorado sites are the Rocky Flats Environmental Technology Site and eight UMTRA sites.*

[5] *Nonweapons contamination in California is found at Lawrence Berkeley National Laboratory, the General Atomics Site, the Geothermal Test Facility, the Laboratory for Energy-Related Health Research, the Energy Technology Engineering Center, and the Stanford Linear Accelerator Center.*

Figure 4-3. Contaminated Media Volume Categorized by Physical Matrix



Media	Volume (m3)
Groundwater	1,800,000,000
Surface Water	490,000
Liquid	460,000
Waste Water	24,000

Media	Volume (m3)
Soil	75,000,000
Other Solid	2,000,000
Rubble/Debris	650,000
Sludge	640,000
Ash	83,000
Sediment	87,000
Metal	11,000
Paper/Cloth	6,500
Residues	1,500
Salts	1,500
Asbestos	1,000
Wood	1,000
Concrete/Brick	400
Gas	190
Asphalt	28

Media	Volume (m3)
Groundwater	1,300,000,000
Surface Water	480,000
Liquid	320,000
Waste Water	5,900

Media	Volume (m3)
Soil	70,000,000
Other Solid	1,700,000
Rubble/Debris	590,000
Sludge	490,000
Ash	83,000
Sediment	63,000
Metal	8,200
Paper/Cloth	1,900
Residues	1,500
Salts	1,500
Asbestos	1,000
Wood	580
Concrete/Brick	400
Gas	180
Asphalt	19

Media	Volume (m3)
Groundwater	350,000,000
Surface Water	850
Liquid	140,000
Waste Water	18,000

Media	Volume (m3)
Soil	5,200,000
Other Solid	400,000
Rubble/Debris	51,000
Sludge	160,000
Ash	0
Sediment	23,000
Metal	2,700
Paper/Cloth	4,600
Residues	6
Salts	0
Asbestos	0
Wood	490
Concrete/Brick	0
Gas	0
Asphalt	9

Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996.
(2) Media volume calculations subject to Endnotes a, b, and c.
(3) Weapons allocations are subject to Endnotes e, f, and g.
(4) Most liquids are groundwater or surface water, but have not been classified as either one.
(5) Includes approximately 1,500 million cubic meters of water and 15 million cubic meters of solid media outside the scope of the Environmental Restoration Program.

M Area settling basin closure site. Metalworking facilities in M Area fabricated fuel and targets for the Savannah River Site's five production reactors. Wastes discharged to the basin from these processes seeped into the groundwater. The wells in the foreground are part of a groundwater treatment system. *M Area Settling Basin, Savannah River Site, South Carolina. June 15, 1993.*

Table 4-5. Contaminated Water Resulting from Nuclear Weapons Production

Site	Nuclear Weapons Volume (m^3)	Nonweapons Volume (m^3)
Ambrosia Lake (NM)	780,000	420,000
Belfield (ND)	160,000	83,000
Canonsburg (PA)	13,000	7,000
Durango (CO)	250,000	140,000
Falls City (TX)	2,900,000	1,500,000
Fernald (OH)	270,000	
GJMTS (CO)	850,000	450,000
GJPO (CO)	90,000	
Green River (UT)	440,000	240,000
Gunnison (CO)	4,600,000	2,400,000
Hanford (WA)	1,200,000,000	210,000,000
INEL (ID)	1	34,000,000
K-25 (TN)	630,000	320,000
Kansas City Plant (MO)	360,000	
Kauai Test Facility (HI)	5,700	
Lakeview (OR)	3,000,000	1,600,000
LLNL (CA)	22,000,000	
LLNL - Site 300 (CA)	3,500,000	
Maybell (CO)	560,000	300,000
Mexican Hat (UT)	280,000	150,000
Monument Valley (AZ)	3,000,000	1,600,000
Mound (OH)	680,000	
Naturita (CO)	250,000	130,000
Nevada Test Site (NV)	8,000	450
ORNL (TN)	260	670,000
Paducah (KY)	19,000,000	1,000
Pantex (TX)	4,200,000	
Portsmouth (OH)	2,400,000	1,600,000
Rifle (CO)	1,700,000	880,000
Riverton (WY)	1,200,000	660,000
Rocky Flats (CO)	1,300,000	
Salt Lake City (UT)	850,000	450,000
Sandia National Laboratory (NM)	400	
Savannah River Site (SC)	200,000,000	
Shiprock (NM)	400,000	210,000
Slick Rock (CO)	98,000	52,000
Spook (WY)	2,500,000	1,400,000
Tuba City (AZ)	2,000,000	1,000,000
Weldon Spring (MO)	710,000	
Y-12 (TN)	930,000	
TOTAL WEAPONS SITES	1,500,000	257,000,000
TOTAL NONWEAPONS SITES	0	93,000,000
TOTAL DOE	1,500,000	350,000,000

Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996.
(2) Media volume calculations subject to Endnotes a, b, and c.
(3) Nuclear Weapons allocations are subject to Endnotes e, f, and g.
(4) Includes approximately 1,500 million cubic meters of water and 15 million cubic meters of solid media outside the scope of the Environmental Restoration Program.

groundwater and contaminated solid media are 95 percent soil. The nonweapons media legacy is similar (89 percent of the solid media is soil and over 99 percent of the water is groundwater).

Release Sites and Other Units

The legacy of contaminated environmental media is present at approximately 9,900 release sites and other units. The Department organizes these units into 10 major categories, which are further subdivided into 36 subcategories (Table 4-6).

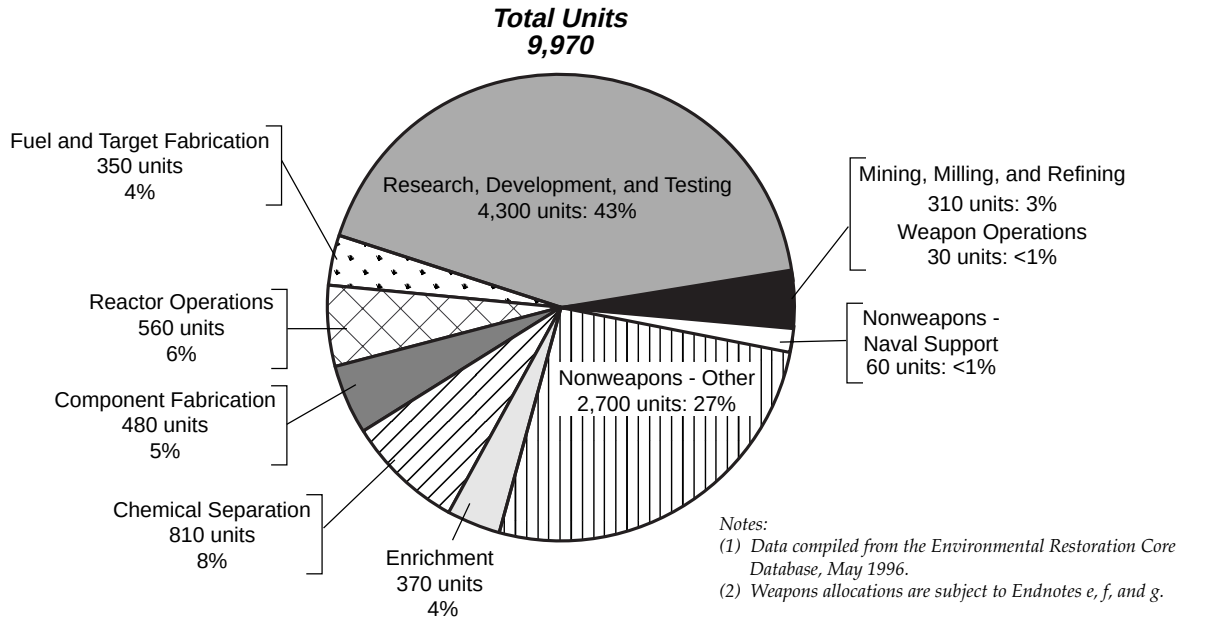
Table 4-6. Categories and Subcategories of Release Sites

Category	Subcategory	Units
Above Ground Material/Waste	Storage Yards and Pads	594
	Debris Piles	143
	Muck Piles	17
	Scrap Yards	49
	TOTAL	803
Surface/Subsurface Material/Waste	Miscellaneous Surface Debris	932
	Landfills	304
	Silos	5
	Trenches/Outfalls	508
	Pits	218
	Burn Pits	126
	Ditches	78
	Fire Training Areas	8
	Wells (Injection, Monitoring, etc.)	78
	TOTAL	2257
Mill Tailings Pile	Uranium Mill Tailings Piles	57
Spills and Leaks	Surface Spills	1079
	Pipeline Leaks	195
	TOTAL	1274
Buildings and Equipment	Buildings or Structures	1389
	Equipment	493
	TOTAL	1882
Tanks	Above Ground Storage Tanks	356
	Underground Storage Tanks	606
	Septic Tanks	250
	TOTAL	1212
Liquid Surface Impoundments	Lagoons	53
	Holding Ponds	109
	Settling and Separation Basins	105
	Seepage Basins	73
	Leach Fields	132
	Sumps	210
	Evaporation Ponds/Pits	82
	TOTAL	764
Underground Test Area Surface and Groundwater	Underground Test Areas	906
	Sediments	45
	Groundwater Plumes	104
	Surface Water	55
	TOTAL	1212
Dispersed Surface Contamination	Land Farms	23
	Above Ground Tests	134
	Firings Ranges/Ordnance	174
	TOTAL	1212
Miscellaneous	Other	204

Of the 9,900 release sites, FUSRAP sites, and UMTRA surface contamination and groundwater sites, and facilities, 73 percent are attributed to weapons production (Figure 4-4). About 43 percent are attributed to weapons research, development, and testing and are located at Los Alamos and the Nevada Test Site (Table 4-7). About 30 percent of the units are attributed to the other seven weapons production activities. Less than 1 percent are attributed to activities supporting the NNPP and about 27 percent are attributed to other nonweapons activities. Most of the nonweapons units are located at Nevada Test Site (primarily from other defense testing activities), Argonne National Laboratory-East, Idaho National Engineering Laboratory, and Oak Ridge Reservation. None of the units attributed to supporting the NNPP are or were operated by or under the purview of the NNPP. Instead, the number of units allocated to supporting the NNPP represents about 27 percent of the units at the uranium mill tailing sites and 7 percent of the units at the uranium enrichment sites.

In addition to Los Alamos and the Nevada Test Site, units attributed to weapons production activities have been identified at 88 other DOE sites in 25 states. Units that were attributed to nonweapons activities are located at 45 of the sites with weapons units, plus another 37 nonweapons sites. The number of sites where these units are found is larger than the number of sites where contaminated media are located because characterization of some units is not complete and, for others, only waste or contaminated structures (not media) may be present at the unit.

Figure 4-4. Release Sites and Other Units Categorized by Process



Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996.
(2) Weapons allocations are subject to Endnotes e, f, and g.

Table 4-7. Locations of Environmental Restoration Release Sites and Other Units

State	Nuclear Weapons Units	Nonweapons Units	Total
NM	2,364	11	2,375
NV	1,666	709	2,375
WA	1,173	158	1,331
SC	373	1	374
OH	290	53	343
TN	253	366	619
TX	240	1	241
CA	213	229	441
CO	203	16	219

State	Nuclear Weapons Units	Nonweapons Units	Total
MO	120	0	120
ID	115	454	569
KY	98	63	159
UT	14	8	22
IL	14	521	534
IA	8	3	11
NY	8	73	81
NJ	5	9	14
HI	3	0	3

State	Nuclear Weapons Units	Nonweapons Units	Total
AZ	3	1	4
ND	3	1	4
WY	3	1	4
PA	3	1	4
OR	2	1	3
AK	1	2	3
MA	1	2	3
MI	1	1	1
Nonweapons Sites (Various States)	0	944	944

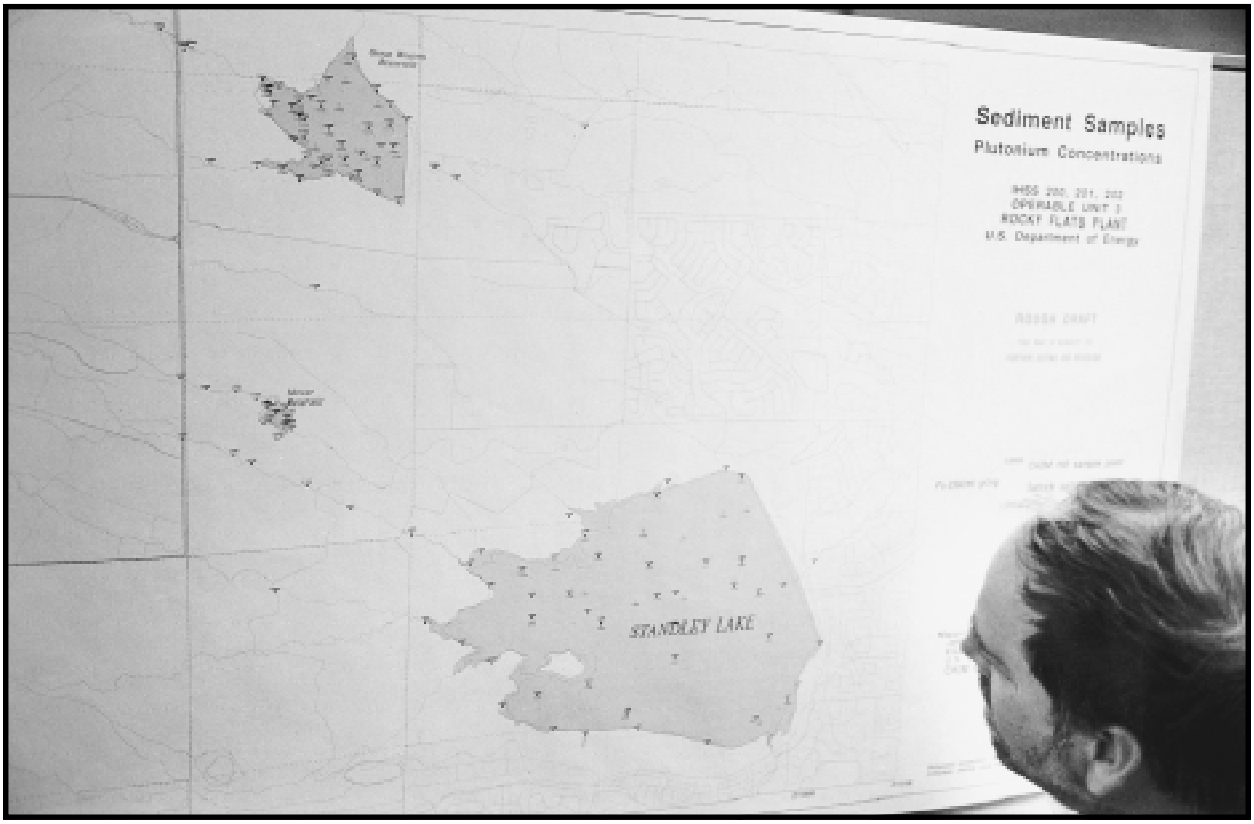
Notes:
(1) Data compiled from the Environmental Restoration Core Database, May 1996 (See Endnote d).
(2) Weapons allocations are subject to Endnotes e, f, and g.

As the Department continues to remediate contaminated environmental media, the total volume and number of release sites and other units will change. Natural decay will decrease the amount of radioactive constituents in the media. Thus, in coming years the legacy of environmental contamination attributable to nuclear weapons production will differ from the quantities identified in this report.

Contamination Not Included in Quantitative Analysis

The volume of some contaminated media resulting from nuclear weapons production and other DOE activities is not tracked in the Core Database. For these media, final decisions about remediation are still pending or cleanup may be impractical or unnecessary. In some cases, the potential human health risks from leaving the contamination unremediated may be less than the risks from remediation. In other cases, removing contamination is impractical or is only possible by destroying the natural habitat that contains it. Examples include:

- Sediments in the East Fork Poplar Creek, the Clinch River, and lower Watts Bar Reservoir contaminated with mercury and other heavy metals, radionuclides and organic chemicals from the Department of Energy sites in Oak Ridge, Tennessee and other industrial, urban, residential, and agricultural sources; and



Characterization and monitoring. A Rocky Flats engineer studies a sediment sampling plan, part of an effort to determine levels of plutonium contamination in the streams, ponds, and reservoirs around the Rocky Flats Site. Sampling plans like this one are used to characterize and monitor environmental contamination throughout the nuclear weapons complex. *Rocky Flats Environmental Technology Site, Colorado. March 19, 1994.*

- Sediments in the 2,640-acre PAR Pond at the Savannah River Site in South Carolina which was contaminated with cesium-137 by releases of reactor cooling water.

In addition to these examples, there have been releases whose results are impossible to locate, fully characterize, or clean up. For example, fallout from over 200 aboveground U.S., Soviet, U.K., French, and Chinese weapons tests is estimated to have raised the current average annual radiation dose by about 0.3 percent (see text box "Radiation from Atmospheric Nuclear Weapons Testing"). There is no practical action that can be taken to locate, remove, or mitigate this contamination, hence no volume estimate is available. Other releases, such as the radioactive releases from early operations at Hanford to the atmosphere and the Columbia River have long ago decayed away (see text box "Radioactive Releases from the Hanford Site"). No contaminated media resulting from these releases exist at the present time.

Some contamination that has already been remediated is not included in the Core Database. One major example is the U.S. nuclear weapons testing sites in the South Pacific. The United States conducted 23 tests on Bikini Atoll and 43 tests on Enewetak Atoll between 1946 and 1958, resulting in substantial contamination to the atolls and nearby areas. Enewetak is located approximately 2,500 miles west of Hawaii and contains 40 named islands, two coral reefs, a small number of inlets, and long stretches of submerged coral reefs. Bikini is located approximately 200 miles east of Enewetak and consists of 25 named islands and unnamed coral heads and islets.

The contamination that resulted from the Pacific tests included high concentrations of cesium-137 and strontium-90 in soils. Neutron activation of steel towers and test device parts led to measurement of high gamma emissions from cobalt-60. Some safety tests also resulted in a measurable localized spread of transuranic elements, including plutonium-239, plutonium-240, and americium-241. Testing on both

Contaminated hillside at Rocky Flats. When drums of plutonium-contaminated oils and solvents corroded and leaked on an outdoor storage pad, this hillside at Rocky Flats became contaminated with plutonium and other toxic substances. Over 5,000 of these drums accumulated while engineers were developing a method to treat the oils for recycling or disposal as non-radioactive waste. The city of Denver, 16 miles away, can be seen in the distance. *Hillside 881, Rocky Flats Environmental Technology Site, Colorado. March 19, 1994.*

atolls also left behind massive reinforced control bunkers, large steel towers used to mount diagnostic equipment, piles of scrap and debris, and much abandoned equipment. The detonations significantly changed the topography of Enewetak—several small islands were totally destroyed.

Table 4-8. Results of Restoration of Bikini and Enewetak Islands

	Bikini	Enewetak
Radioactively Contaminated Debris	500 tons	5,883 cubic yards
Nonradioactive Debris	40,000 tons	253,650 cubic yards
Contaminated Soil		104,097 cubic yards

The Departments of Energy, Defense, and Interior conducted joint cleanup operations at Bikini in 1969 and at Enewetak from 1977 through 1980. As shown in Table 4-8, the restoration generated substantial volumes of debris and soil.

The cleanup at Bikini included the disposal of radioactive scrap metal in the ocean at depths greater than 150 feet at least one mile offshore.[6] Nonradioactive debris was placed in landfills and the U.S. staff built new buildings for Bikini residents. At Enewetak, all radioactive materials were transferred to the island of Runit and entombed in the crater of the Hardtack I Cactus Test conducted in 1958. The tomb was created by sealing the cracks in the crater, mixing plutonium-contaminated soil with cement to form a

[6] *These debris are not included in the ocean-dumped low-level waste discussed in Chapter 3.*

Radiation from Atmospheric Nuclear Weapons Testing

Contamination resulting from atmospheric nuclear explosion is impossible to locate, contain, or remediate. However, because it effects the entire population of the Earth, it is the most significant impact of nuclear weapons on the environment.

Between 1945 and 1962, the United States conducted 210 atmospheric nuclear tests. The former Soviet Union, the United Kingdom, France, and the People's Republic of China have also tested nuclear weapons in the atmosphere. The total yield from all atmospheric nuclear weapons testing was approximately 540 megatons, including 215 megatons from fission. U.S. testing accounts for approximately 30 percent of this total and the former Soviet Union is estimated to be responsible for nearly 60 percent.

Environmental contamination from atmospheric nuclear weapon testing results from (1) fission products, largely beta and gamma radiation emitters such as strontium-90 and cesium-137; (2) neutron activation of weapon materials and materials in the natural environment, such as carbon-14 from activated atmospheric nitrogen and cobalt-60 from steel weapon parts and support towers; and (3) unused nuclear fuel, such as uranium, plutonium, or tritium.

Environmental radiation from atmospheric nuclear weapons tests has declined since atmospheric testing was halted in 1963, and will continue to decline in the future. In 1987, the National Council on Radiation Protection estimated that atmospheric nuclear weapons testing contributed approximately one millirem to the average effective radiation dose of each person in the United States. By comparison, the average annual dose from naturally occurring background radiation is 300 millirem. Actual individual doses may be higher or lower, depending on location, diet, age, and other factors.

Scientists believe radiation health effects to be cumulative over a person's lifetime. Over their lifetime, individuals born before July 1945 will receive an average equivalent radiation from past nuclear weapons testing of 75 millirem from all external sources and from 2 to 65 millirem each to various internal organs (particularly the lungs and bone marrow). With the exception of exposure to carbon-14, most of this dose has already occurred. Younger persons will receive smaller lifetime doses, on average. Again, individual doses may be higher or lower than this average, depending on location, diet, age and other factors.

References:

United States Nuclear Tests, July 1945 through September 1992, U.S. Department of Energy. December 1994. DOE/NV-209 (Rev. 14).

Recommendations of the National Council on Radiation Protection and Measurements. September 1, 1987. Ionizing Radiation Exposure of the Population of the United States. NCRP Report No. 93.

Recommendations of the Council on Radiation Protection and Measurements. December 30, 1987. Exposure of the Population of the United States and Canada from Natural Background Radiation. NCRP Report No. 94.

United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). 1982. Ionizing Radiation: Sources and Biological Effects. 1982 Report to the General Assembly.

slurry, and pumping the slurry into the crater around the contaminated debris. The solid mass was covered by an 18-inch thick concrete cap. Runit remains quarantined and restricted from further use.

Besides the Department of Energy, other organizations are remediating other sites contaminated as a result of the legacy of nuclear weapons production. For example, under an agreement with the Environmental Protection Agency, the General Electric Company is remediating the South Valley Superfund Site in Albuquerque, New Mexico, which was placed on the National Priorities List in 1983. Between 1952 and 1966, the AEC fabricated weapons components at the South Albuquerque Works, a metalworking facility at South Valley. Between 1967 and 1984, the Air Force produced jet engines at the site. General Electric bought the site in 1984. At this site, DOE is providing about 43 percent of the funding for the cleanup, with the balance being provided by six other responsible parties. Contaminated groundwater at South Valley underlies about 74 acres and has an estimated volume of about 330 million cubic meters. However, because DOE is not managing this project, it has not been included in the quantitative results

Radioactive Releases from the Hanford Site

Environmental releases which have long ago decayed away are still a matter of concern to the Department of Energy and its stakeholders. Dose reconstruction studies are a key aspect of the Department's response to these past releases.

The Hanford Environmental Dose Reconstruction Project analyzed radiation releases from the Hanford site and calculated the resulting radiation doses to the surrounding population. Two of the most significant releases of radiation from Hanford are discussed here. Most of the original radionuclides have long since decayed away, although a few of their daughter products may remain in the environment today.

Iodine-131 Releases to the Atmosphere, 1944-1947

When uranium is fissioned in a nuclear reactor, a large variety of radioactive fission products are created. One of the most common of these fission products is iodine-131. Iodine-131, with a half-life of eight days, decays into non-radioactive xenon. Radioactive iodine gas was vented to the plant stacks and dispersed by the wind when spent nuclear fuel from the B, D, and F production reactors at Hanford was dissolved in the T and B plant reprocessing facilities, and to a lesser extent during subsequent steps in the bismuth phosphate separation process. This iodine-131 settled on the ground and rivers, and entered the food chain. The historic iodine-131 releases totaled approximately 685,000 curies between December 1944 and December 1947. After December 1947, irradiated fuel was cooled for a longer period, allowing natural decay to eliminate much of the radioactive iodine. Later on, filters and scrubbers were installed in the exhaust stack system, which further reduced iodine-131 emissions.

Radionuclide Releases to the Columbia River, 1944-1971

Beginning in September 1944 with the initial startup of B Reactor, eight single-pass reactors operated at the Hanford site. The single-pass reactors used Columbia River water to cool the fuel elements in the reactor core. Cooling water flowed around the fuel elements in process tubes in the reactor cores, was stored temporarily in retention basins, and then was released to the river. A ninth reactor, N Reactor, did not discharge directly to the Columbia River. The last single-pass reactor was shut down in 1971. Radionuclides were created when neutrons in the reactor core activated native elements present in the inlet cooling water from the Columbia river, as well as elements that were added by water treatment processes. The reactors also activated elements in the alloys used for process tubes and fuel cladding and materials held in the films deposited on the tube and cladding surfaces. The resulting radionuclides were released in the cooling water discharges to the Columbia River. Uranium fuel element failures caused additional radionuclide releases.

Median estimates of radionuclide releases to the Columbia River, corrected for decay at the time of release, are as follows:

Radionuclide	Half-Life	Total Release 1944 - 1971
sodium-24	15.0 hours	12,600,000 Ci
phosphorus-32	14.3 days	229,000 Ci
scandium-46	83.7 days	120,000 Ci
chromium-51	27.7 days	7,190,000 Ci
manganese-56	2.5 hours	79,600,000 Ci
zinc-65	245 days	491,000 Ci

Radionuclide	Half-Life	Total Release 1944 - 1971
gallium-72	14 hours	3,690,000 Ci
arsenic-76	26.3 hours	2,520,000 Ci
yttrium-90	64 hours	445,000 Ci
iodine-131	8 days	47,900 Ci
neptunium-239	2.4 days	6,310,000 Ci
gross nonvolatile beta emitters*		66,300,000 Ci

Environmental dose reconstructions are underway at the Savannah River Site, Fernald, Idaho National Engineering Laboratory, Rocky Flats, and Oak Ridge.

References:

U.S. Department of Energy, Pacific Northwest Laboratory. October 1992. Iodine-31 Releases from the Hanford Site, 1944 Through 1947, Volume I -Text. PNDWD-2033-HEDR-Vol. 1. DOE Office of Science and Technical Information.

U.S. Department of Energy, Pacific Northwest Laboratory. May 1994. Radionuclide Releases to the Columbia River from Hanford Operations, 1944-1971. PNDWD-2223-HEDR-Vol. 1. DOE Office of Science and Technical Information.

** The largest contributor to this category (15 to 30 percent) is manganese-56. However, it includes other radionuclides that were never definitively identified. It also does not include volatile beta emitters such as tritium and sulfur-35.*

presented in this report. No estimate of the portion of this contamination attributable to nuclear weapons production is available.

Methodology and Data Sources

Data Sources

The Office of Environmental Restoration Core Database contains most of the volume and media characteristics available for this element of the legacy. This database includes information on contaminated media volumes, site locations, physical matrix of the media, and type of contamination. The database also contains information on individual contaminants present in the media, and the expected future disposition of the contaminated media (e.g., *in situ* treatment, *in situ* disposal, removal and treatment, removal and disposal). It also includes limited data used to infer the weapons production process category or nonweapons activity that resulted in the contamination.

Specifics on the release sites and other units came from a database developed by the Office of Environmental Restoration that is being combined with the Core Database. In the release site database, each release site or unit has a name and the location and type of unit is identified.

Contaminated media volumes and radioactivity figures are rounded to two significant figures because of the uncertainties and approximations discussed here. Because of this rounding, some numbers may not appear to add correctly.

Data Issues and Assumptions

The primary data sources for contaminated environmental media are the Environmental Restoration Core Database and a similar Environmental Restoration program database of release sites and other units.

Some of solid media are also counted as disposed waste. This amount comprises approximately three to four percent of the total volume of contaminated solid media.

Some contaminated media outside the scope of the current Environmental Restoration program are not included in this analysis. Contaminated media managed by organizations other than DOE also are excluded. Therefore, the total amount of contaminated media resulting from DOE activities is underestimated in this analysis. Some of these volumes are very large, however, most of these media are groundwater and sediments.

Volumes of material identified in the Core Database categorized as stored waste, equipment, and structures are excluded from the contaminated media analysis and are accounted for as either waste (Chapter 3) or facilities (Chapter 5). Media to be generated in the future from facility decontamination and decommissioning are also excluded from this analysis (and accounted for in Chapter 5). In addition, media that do not contain contamination requiring special management (sanitary waste or demolition debris) are not included in the analysis.

Limitations, Uncertainties, and Assumptions

Each type of media in the Core Database was examined to determine whether it should be included in the contaminated media analysis. Specifically, it was examined to determine its status, its location, its composition, and whether it resulted from nuclear weapons production.

Evolving Data – Most contaminated media in the DOE Environmental Restoration program are currently undergoing characterization or remediation. For some sites, the Department has already completed interim or final remedial actions. DOE maintains a database of about 9,900 release sites and other units and nearly 6,000 vicinity properties. The Department has been characterizing release sites intensively for the last several years, and now has an understanding of many of the contaminated media at these sites. However, the characterization remains incomplete and existing data has yet to be compiled at a nationwide level. Characterization and data compilation will continue in the coming years, and will further improve the Department's understanding of this legacy element

Categorizing Release Sites and Other Units into Nuclear Weapons and Nonweapons Categories – In the database of release sites and other units, the name and location of the unit determined whether the unit resulted from nuclear weapons or nonweapons activities. Because some sites conducted multiple activities,

fractions of individual release sites are attributed to various activities. The units at mill tailings sites and uranium enrichment sites were categorized in the same manner as contaminated media and waste.

Categorizing Environmental Media – To allocate the media to nuclear weapons or nonweapons activities, individual volumes of media from a single project were often divided among several nuclear weapons processes and nonweapons activities. Site and project descriptions in the Core Database determined whether the media resulted from nuclear weapons production and the weapons production process category. The approach used to categorize contaminated media at mill tailing sites and uranium enrichment sites is the same used to categorize waste at those sites. For media at other sites, allocations were based on the historical operations and nature of contamination at each site.

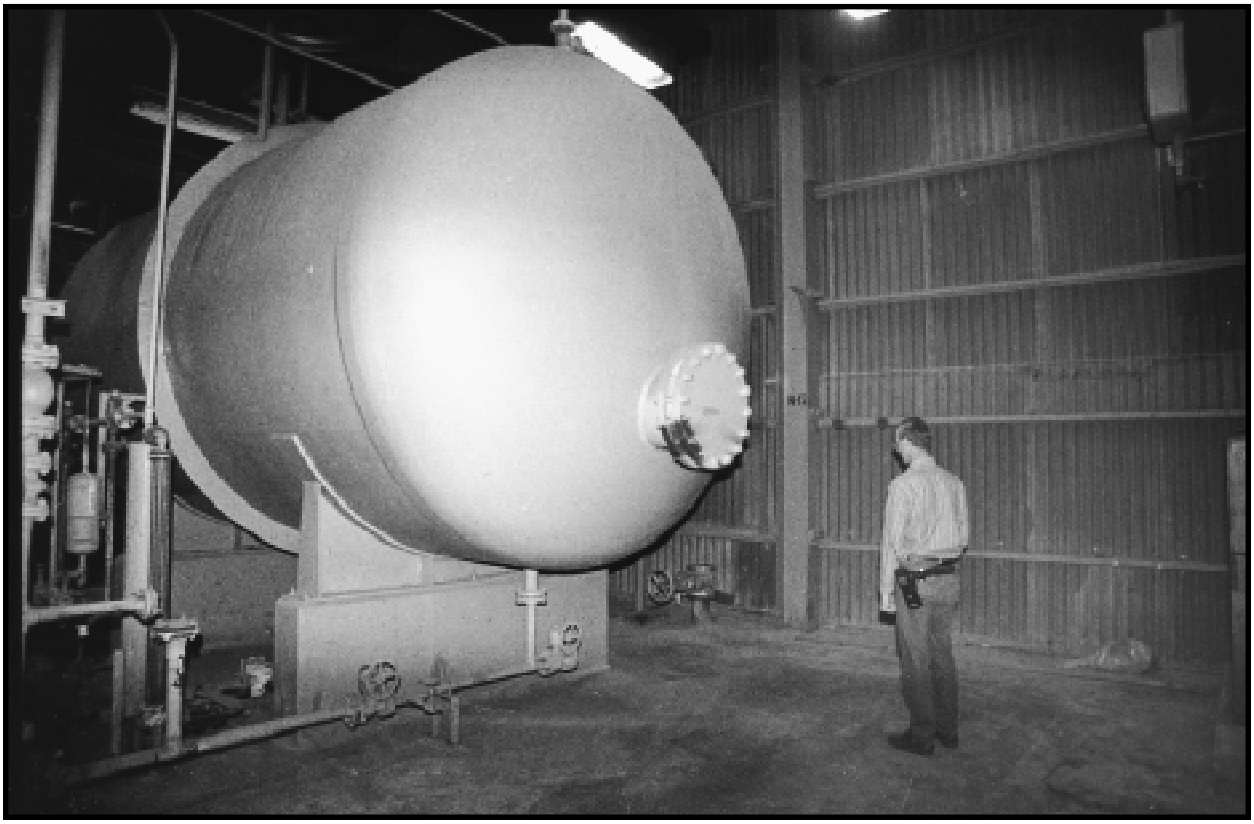
Excluding Volumes of Material from Contaminated Environmental Media Legacy – Some volumes of material identified in the Core Database were excluded from the analysis of contaminated media because they were included in other elements of the legacy (i.e., 33 million m^3 of stored 11e(2) byproduct material, 6 million m^3 of structures and equipment which are counted as facilities, and 12,000 m^3 of media expected to be generated in the future from facility decontamination and decommissioning). Other volumes are excluded because they did not contain hazardous or radioactive contamination at levels requiring special management (i.e., 215 million m^3 of media categorized as sanitary, demolition, or nonhazardous). For example, some water discharges at Fernald contain levels of uranium contamination low enough that they do not require special management. Media that are not managed by DOE, or for which no volume estimate was available, were also excluded. All other volumes of media were included and were categorized as either hazardous, radioactive, or both hazardous and radioactive.

Ambiguities in Defining and Quantifying the Contaminated Environmental Media Legacy – Interpretations differ as to what constitutes "contaminated environmental media" and what should be tracked as "contaminated environmental media." The portion of contaminated environmental media under active management (e.g., being treated, contained, removed, or subject to institutional controls) is often well established. Data developed by DOE sites and compiled into the Core Database are available on the volumes and characteristics of these media.

The problem resulting from release of a contaminant can be defined in several ways, and each definition can result in a different volume. The definition most often used by DOE in determining the volume of affected media that should be tracked and commonly used by stakeholders and regulatory agencies is the volume of environmental media in which the contaminant is thought to be present above an action level. This approach is subject to some inevitable uncertainties because of shortcomings of the characterization technology, statistical uncertainties introduced in the characterization process itself, and modeling uncertainties in using the data to determine where contaminants are now or to predict where they may migrate in the future.

Other definitions, for example, the volume of the contaminant released to the media, the volume of media containing contaminants above detection levels, the volume of groundwater to be pumped to the surface for treatment, or, in the case of a contaminated aquifer, the entire aquifer which must be specially managed to prevent the spread of contamination, can result in much larger or smaller volumes. Some definitions, such as the volume of the material released, provide results with limited use because they do not consider how the contaminants have affected the environment or the risks they pose to humans.

For example, at the Y-12 Plant in Oak Ridge, Tennessee an estimated 240,000 pounds of mercury metal used in the lithium enrichment process are thought to have been released to the surface water around the site (Table 4-9). In its pure form, this mercury amounts to about 20 cubic meters (5,300 gallons). However, the volume of contaminated sediments resulting from the releases is many thousand cubic meters. Some of the sediments will be cleaned up, and the remainder may be subject to future restrictions. Another example is the Hanford Site, where it is estimated that 346 billion gallons of liquids containing 1.4 million curies of various radionuclides were discharged into the soil between 1944 and 1991. As a result, there are 1.4 billion cubic meters (25 billion gallons) of contaminated water and 23.6 million cubic meters (3.8 billion gallons) of contaminated soil.



Lithium enrichment equipment. An engineer stands before a 20,000 gallon storage tank inside the Oak Ridge Y-12 Plant. This tank once held a lithium solution that was combined with mercury in the COLEX lithium-enrichment process. Enriched lithium is used in thermonuclear weapons; it is also irradiated in reactors to create tritium for nuclear weapons. Mercury in the waste streams from lithium-enrichment in the 1950s and 1960s has contaminated streams and sediments around the Y-12 Plant. *Basement of the Alpha-4 (9201-4) Building, Y-12 Plant, Oak Ridge, Tennessee. January 11, 1994.*

Table 4-9. Results of Y-12 Mercury Release Reconstruction Study

Mercury Lost, Spilled, or Dumped to Environment	Estimated Pounds of Mercury[b]
Lost to air (1950-1963)	51,000
Lost to East Fork Poplar Creek (1950-1982)	239,000
Lost to ground under Y-12	428,000
Lost to sediments in New Hope Pond	15,000
Subtotal Lost	733,000
Additional Mercury Not Accounted For	51,000
Did not receive[a]	500,000
In building structures[a]	60,000
Other specific losses[a]	85,000
Unknown	655,000
Subtotal All Other	1,300,000
TOTAL	2,030,000

[a] *These estimates are speculation and cannot be verified. Source: Mercury at the Y-12 Plant, A Summary of the 1983 UCC-ND Task Force Study, Martin Marietta Energy Systems, Inc., November 1983.*

[b] *One pound (0.45 kg) of metallic mercury would form a cube approximately 1.26 inches (.,2 cm) on a side.*

The Core Database generally identifies the established or expected actions applicable to each volume of media. In some cases, however, decisions have not been made on what, if any, actions should be taken, at what level the site-specific action should exist, or on what volumes of media are subject to the actions. If all media volumes identified in the Core Database as "no further action" were excluded from tis analysis, the volume of contaminated environmental media would be smaller. Additionally, the volume would be larger if other contaminated media volumes not identified in the Core Database were considered (since they are outside the scope of the current Environmental Restoration Program).

Finally, the Department gathers detailed characterization information on media that it believes can and will be remediated. In many cases where decisions are made to monitor so as to ensure that contaminants do not reach receptors, to allow natural attenuation to occur, or to take no action because practical technologies do not exist or risk levels do not justify action, the Department does not collect and maintain the same type of volume information as for actively managed media, and the collected data are not included in the Core Database. Estimates of the volumes of these media have been obtained from other sources when possible.

SUMMARY

The Department's legacy of contaminated environmental media consists of two categories of material: water and solid media. Different management requirements and alternatives exist for each category. Most of the volume of contaminated environmental media is groundwater. These media are present at several thousand specifically-identified release sites and other units across the DOE complex. The greatest uncertainties concerning the volume of contaminated media are the volume of contaminated

RCRA cap. Ten acres of black plastic cover a radioactive waste landfill in Oak Ridge. This high-density polyethylene cap is designed to prevent gases from escaping, reduce erosion, and keep rainwater from leaching contaminants into the groundwater. Installed in 1989, the cap is designed to last 15 to 20 years. *Solid Waste Storage Area 6, Oak Ridge Reservation, Oak Ridge, Tennessee. January 10, 1994.*

media outside the scope of the current Environmental Restoration program. As contaminated media and release sites continue to be characterized and, remediated, new data will become available and estimates will be improve.

ENDNOTES

a. Environmental Restoration Core Database, containing data current as of May 1996, was used as a source for volume data of water and solid media. Volumes of material categorized as stored waste in the database are included in Chapter 3 (Waste); volumes of material categorized as structures/equipment are accounted for in Chapter 5 (Facilities). Some contaminated media volume data are not recorded in the database and are not included in this analysis. Volume estimates of contaminated media at some sites change over time as better data is compiled or as contamination spreads or is cleaned up. Media classified as groundwater, surface water, wastewater, and liquid are categorized as water. All other media are classified as solid media. The volume of contaminated groundwater in the current Core Database likely underestimates the true extent of groundwater contamination since characterization information for this medium is preliminary.

b. Volumes of water and solid media from the Environmental Restoration Core Database that are classified as sanitary, demolition debris, or "NA" are not included. Volumes of water and solid media classified as MTRU, MLLW, 11e(2), RPCB, and RASB in the database are categorized as both radioactive and hazardous/toxic; volumes classified as TRU, LLW, and 11e(2) byproduct material are categorized as radioactive only; volumes classified as HAZ, PCB, and ASB are categorized as hazardous/toxic only. The classifications of contaminated media at some sites may change over time as characterization data continues to improve, regulations change, or as categories are redefined.

c. Media volumes from the Environmental Restoration Core Database that are projected to result from future decontamination and decommissioning activities are not included and are accounted for in Chapter 5 (Facilities), except for soil, sediment, groundwater, surface water, and liquid.

d. Environmental Restoration Release Site Database, containing data current as of April 1996, was used as a source for data on release sites and other units. Contaminated media have not been quantified at all units. Some units contain only stored waste, and characterization is not complete as some units.

e. Allocations are generally based on the processes conducted at the sites where the media or unit is located. For multipurpose sites, allocations are based on media descriptions in the Environmental Restoration Core Database and unit names in the Release Site Database. In cases where the media description or unit name is not adequate to determine the allocation, an estimated sitewide allocation was applied, based on waste allocations used in Chapter 3.

f. For media and units at uranium enrichment sites (K-25 Site and the Paducah and Portsmouth Gaseous Diffusion Plants), allocations are based on the proportions of enriched uranium produced for various purposes (nuclear weapons program, naval fuel, research reactors, nonweapons programs), as measured in separative work units, and taking into account when uranium was enriched. This allocation is only an estimate. Historic records may also be available that would allow media to be allocated based on the specific causes of contamination. For allocations to naval fuel production at these sites, DOE is responsible for the management of all units and media. The NNPP is not currently involved in the management of these sites and has not been involved in the past.

g. For media and units at uranium mill tailing sites, media are allocated based on the uranium purchaser (AEC or non-AEC) and, for AEC-purchased uranium, according to the use of the eventual uranium product (nuclear weapons program, naval fuel, research reactors, nonweapons programs). The same allocation is applied to all mill tailing sites, taking into account all historic AEC uranium purchases including uranium purchases from sites where DOE is responsible for remediation, other U.S. mill tailing sites, and foreign mill tailing sites. This allocation is only an estimate. See the text box in Chapter 3 for a further explanation of this allocation. For allocations to naval fuel production at these sites, DOE is responsible for the management of all units and media. The NNPP is not currently involved in the management of these sites and has not been involved in the past.